

APR 15 1968

Bellcomm/1/1968

FM-files



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 68-FM-87

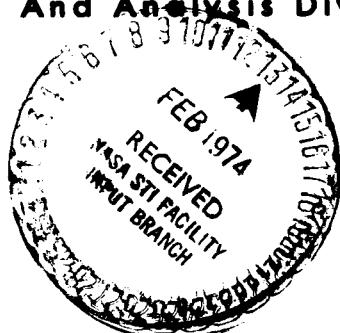
OCT 30 1969

April 3, 1968

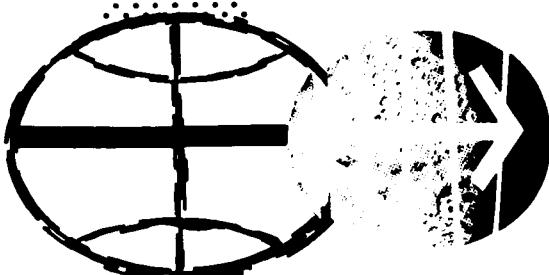
Technical Library, Bellcomm, Inc.

MPAD VERIFICATION OF APOLLO 6
(A-2/CSM-020) FLIGHT MISSION RULES

By Mission Planning And Analysis Division



MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

(NASA-TM-X-69647) MPAD VERIFICATION OF
APOLLO 6 (A-2/CSM-020) FLIGHT MISSION
RULES (NASA) 28 p

N74-70500

Unclas
00/99 16184

MSC INTERNAL NOTE NO. 68-FM-87

PROJECT APOLLO

MPAD VERIFICATION OF APOLLO 6
(A-2/CSM-020) FLIGHT MISSION RULES

By Mission Planning and Analysis Division

April 3, 1968

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved:

Carl R. Huss
Carl R. Huss, Assistant Chief for
Mission Design

Approved:

John P. Mayer
John P. Mayer, Chief
Mission Planning and Analysis Division

CONTENTS

	Page
FOREWORD	iv
Mission Rule No. 4-17	1
Mission Rule No. 4-23	2
Mission Rule No. 4-24	3
Mission Rule No. 4-26	4
Mission Rule No. 4-28	6
Mission Rule No. 4-29	7
Mission Rule No. 4-30	8
Mission Rule No. 4-33	9
Mission Rule No. 4-37	10
Mission Rule No. 4-84	11
Mission Rule No. 4-86	12
Mission Rule No. 4-87	14
Mission Rule No. 4-88	15
Mission Rule No. 4-89	16
Mission Rule No. 5-34	18
Mission Rule No. 10-7	20
Mission Rule No. 10-12.	22
REFERENCE	24

FOREWORD

The Mission Planning and Analysis Division (MPAD) has conducted an internal verification review of the Apollo 6 (A-2/CSM-020) Flight Mission Rules which were additions to or revisions of the Apollo 5 rules. (See the reference.) Each rule was reviewed with regard to the MPAD's contribution to the creation, verification, or justification of the rule and, also, to the MPAD's agreement or disagreement with the rule.

This document presents the results of the MPAD's internal verification review and contains the following information about each rule which falls within the MPAD's area of responsibility: background or clarifying statements that may be pertinent to why the rule was necessary, the data the rule was based on, limitations that exist, if any, etc.; statements concerning disagreements; and a list of references which substantiate the rule. Where disagreement with a rule was discovered, the disagreement was discussed with the responsible flight controller and in most cases was resolved and is so stated.

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-17	G&N failure in earth parking orbit, precludes executing SPS 1 maneuver in a guided mode.	FDO pass SPS 1 maneuver to flight for execution in SCS ΔV mode.	Maneuver data will include: A. GETIG B. S/C attitudes. C. GETCO D. ΔV _{man} E. ΔT _{man}

PHILOSOPHY:

If the G&N fails in earth parking orbit, the SPS-1 burn will be performed in the stabilization and control subsystem (SCS) ΔV mode. The abort maneuver is monitored both on plotboard and digital displays. The FDO Burn Analog No. 5 (ref. 1) display shows V_E as a function of V_E during the burn, while the FDO Maneuver Monitor No. 3 display shows h_a as a function of h_p . The same parameters are available via digital readout. The burn is allowed to continue until it is determined that the entry corridor centerline is reached.

COMMENTS: None

REFERENCES:

1. Final Flight Dynamics Displays for the A-2/CSM 020 (Apollo 6) Mission. MSC Memo 68-FM36-110, March 8, 1968.
2. Preliminary Abort Procedures to Cover G&N Failures During TLI Burn of the A-2/CSM 020 (Apollo 6) Mission. TRW IOC 3423.6-315. February 7, 1968.

Date:

Verified by: A. N. Lunde

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-23	During the second S-IVB burn the trajectory exits mission capability area after entry into this area.	FDO sends MCP SEP (RTC 71)	Assures that once the capability to achieve both SPS 1 and SPS 2 targets is achieved, it will not be lost.

PHILOSOPHY:

The mission capability area is the region in which there exists SPS capability of achieving both SPS burn targets. This area is based on the alternate mission sequence assuming RTC-71 is commanded 10 seconds after S-IVB shutdown and is biased 3.5 seconds for data transmission delay. Once the S-IVB burns into this area, it will not be allowed to lose the capability thus achieved.

COMMENTS:

The S-IVB should not be allowed to exit the mission capability area once being in the area. If this happens, the second SPS burn target cannot be achieved. The S-IVB burn should be monitored on the $V_i - \gamma_i$ orbit plotboard.

REFERENCE:

1. Final Flight Dynamics Displays for the A-2/CSM 020 (Apollo 6) Mission. MSC Memo 68-FM36-110, March 8, 1968.

Date:

Verified by: A. N. Lunde

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-24	S-IVB C/O prior to crossing retrograde SPS 1 line.	FDO send MCP SEP (RTC 71)	SLV turnaround to retrograde attitude with posigrade SPS 1 following results in possible recontact problem.

PHILOSOPHY:

The retrograde SPS-1 indicates the area in which the first SPS burn should be retrograded. If the S-IVB has a premature cutoff prior to crossing this line, the SPS-1 should be fired in a posigrade attitude, so as to increase the apogee to the desired value. The retrograde SPS-1 line is shown on the $h_a - h_p$ plotboard (ref. 1, fig. 10).

COMMENTS: None

REFERENCE:

1. Final Flight Dynamics Displays for the A-2/CSM 020 (Apollo 6) Mission. MSC Memo 68-FM36-110, March 8, 1968.

Date:

Verified by : A. N. Lunde

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-26	During SPS 1, one of the following conditions is confirmed:	FDO send SPS OFF (RTC 12)	The SPS 1 entry area is defined by the following lines: A. Apogee $>12K$ n.mi. and increasing. B. Trajectory exits the SPS 1 entry area after entry into this area. C. $h_a \leq 10K$ n.mi. and decreasing. Trajectory is not within the SPS 1 entry area.

PHILOSOPHY:

- A. During the first SPS burn the apogee altitude nominally decreases from 280 000 n.mi. to 12 000 n.mi. (ref. 2, p. 81). If during this burn the apogee becomes >12 000 and increasing, the burn should be terminated.
- B. The SPS-1 burn should be shut down if the trajectory exits the SPS-1 entry area shown on the $h_a - h_p$ plot-board (ref. 1, fig. 10). This plotboard displays the instantaneous orbit conditions. The SPS-1 entry area is defined by the following four lines:
1. The 20g full-lift undershoot line which defines the apogee/perigee conditions that will result in a 20g entry.
 2. The SPS-1 overspeed line which represents the locus of trajectories resulting from the maximum allowable first SPS overspeed which still retains sufficient SPS propellant to achieve the second SPS target. This line is biased 3.5 seconds for data transmission delay.
 3. Zero-lift 3500 n.mi. range overshoot line.
 4. SPS-1 underspeed line (16 000 n.mi. apogee line) which dictates an SPS-1 shutdown because of telemetry and systems lifetimes constraints.

- C. If the $h_a \leq 10\ 000$ n.mi. and decreasing during the first SPS burn, the burn should be terminated, since the trajectory is not within the SPS-1 entry area and diverging from the desired apogee altitude.

COMMENTS: None

REFERENCES:

1. Final Flight Dynamics Displays for the A-2/CSM 020 (Apollo 6) Mission. MSC Memo 68-FM36-110, March 8, 1968.
2. Apollo 6 (A-2 or AS-502/020) Operational Spacecraft Abort Plan. MSC IN 68-FM-58, February 26, 1968.

Date:

Verified by: A. N. Lunde

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-28	20g undershoot/G&N fail line exceeded during the SPS 2 burn.	FDO transmit SPS Off (RTC 121)	Condition recognized on the VEI VEI display.

PHILOSOPHY:

The 20g undershoot/G&N fail line was selected as the FIDO burn cutoff line in order to keep the CM out of two areas of the corridor (ref. 1).

These areas are:

1. The part of the corridor where the G&N may have to be failed in order to protect against the CM going below .01g while in the final phase guidance logic. This problem area is discussed in reference 2.
2. The part of the corridor where the backup mode is sensitive to executive errors. This is discussed in reference 3.

Each of these lines contains a 10-second time bias for data delays.

COMMENTS: None

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center. MSC Memo 68-FW53-89, March 4, 1968.
2. Evaluation of Variations in Touchdown Target Placement for the A-2/CSM 020 (Apollo 6) Guidance and Navigation (G&N) System. TRW IC No. 3423.5-228, March 22, 1968.
3. Ranges for the A-2/CSM 020 Mission Backup Bank Angle Modes. TRW IC No. 3423.5-233, March 14, 1968.

Date:

Verified by: J. C. Harpold

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-29	Overshoot boundary line exceeded during either SPS burn.	FDO transmit SPS Off (RTC 12)	A. Condition recognized on the h_a vs h_p plot or the γ_{EI} vs V_{EI} plot. B. For SPS 1, this rule becomes valid only after entry range is initially established at less than 3500 n.mi.

PHILOSOPHY:

The overshoot boundary used to cut off the SPS burn is a 10 second time biased zero lift overshoot boundary. This line is based on the worst case L/D and atmosphere (.411 L/D and 60° north thin atmosphere).

COMMENTS:

Above this line a backup mode entry cannot be guaranteed without at least an initial lift-vector-down attitude. Even with lift-vector-down initially, a large entry range may result if the flight-path angle is shallow (above the zero lift overshoot boundary based on nominal conditions).

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center. MSC Memo 68-FM53-89, March 4, 1968.
3. Ranges for the A-2/CSM 020 Mission Backup Bank Angle Modes. TRW IC No. 3423.5-233, March 14, 1968.

Date:

Verified by: J. C. Harpold

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-30	Overspeed line exceeded during the SPS 2 burn.	FDO transmit SPS Off (RTC 12)	Line is based on predicted velocity at 400K feed equal to 36.5K fps.

PHILOSOPHY:

This constant velocity lines exists so that the maximum velocity at entry interface can not be greater than 36 760 fps. This line has a 10-second bias built into it which amounts to 260 fps. At entry velocities greater than 36 760 fps, the G&N system performance is significantly degraded and the backup modes become highly sensitive to execution errors.

COMMENTS: None

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center. MSC Memo 68-FM53-89, March 4, 1968. ∞
2. Evaluation of Variations in Touchdown Target Placement for the A-2/CSM 020 (Apollo 6) Guidance and Navigation (G&N) System. TRW IC No. 3423.5-228, March 22, 1968.
3. Ranges for the A-2/CSM 020 Mission Backup Bank Angle Modes. TRW IC No. 3423.5-233, March 14, 1968.
4. A-2/CSM 020 (Apollo 6) Entry Guidance and Navigation (G&N) System Operation. TRW IC No. 3423.5-230, March 19, 1968.

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-33	G&N fail with the no burn full lift entry loads exceeding the structural limit of the space-craft.	<p>FDO will recommend burning the SPS in the SCS AV mode to obtain a satisfactory trajectory.</p> <p>A. Burn attitudes plus allowable dispersions.</p> <p>B. GET of burn initiate.</p> <p>C. GET of cutoff.</p> <p>D. Time of free fall to 400 000 ft at a GET of SPS cutoff.</p>	The SPS burn will permit a full lift entry. The data FDO supplies for the burn is as follows:

PHILOSOPHY:

Reentry flight limits must limit the reentry aerodynamic loads to less than 20g.

COMMENT:

Below this line, the CM will experience more than 20g which is the structural limit of the spacecraft. This line is based on the worst case L/D and atmosphere. ($L/D = .297, 60^\circ$ north thin atmosphere).

REFERENCE:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center, MSC Memo 68-FM53-89, March 4, 1968.

Date:

Verified by: J. C. Harpold

Revision No./Date A 2/28/68

Rule No.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-37	Structural full lift entry limit exceeded during SPS abort burn.	FDO transmit SPS Off (RTC 12)	A. Condition shown on the •EI vs VEI display.

PHILOSOPHY:

The reentry flight limits must limit the reentry aerodynamic loads to less than 20g.

COMMENT:

Below this line, the CM will experience more than 20g, which is the structural limit of the spacecraft. This line is based on the worst case L/D and atmosphere. (L/D = 0.297, 60° north thin atmosphere).

REFERENCE:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center. MSC Memo 68-FM53-89, March 4, 1968.

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-84	G&N entry attitude control problem will occur because of SPS cutoff conditions.	<p>A. After SPS 1 cutoff and no SPS 2 planned.</p> <p>A. Update entry target point.</p> <p>B. After SPS 2 cutoff.</p>	<p><u>Notes:</u></p> <p>1. Entry target will be updated to an entry range = 625 n.mi. unless recovery or land constraints exist.</p> <p>2. If update cannot be made, part "B" of this rule applies.</p> <p>B. Fail G&N after maneuver to entry attitude and fly SCS entry (full lift).</p>

PHILOSOPHY:

For the Apollo 6 mission, there exists an area in the reentry corridor (ref. 1) where the G&N system may have to be failed because of an attitude control problem. This problem is discussed in detail in reference 2 and involves the CM skipping out of the atmosphere (0.01g) and not resuming an attitude hold mode. If this condition exists after SPS 1, a target update to an entry range of 800 n.mi. can be made, and a G&N entry can be performed. After SPS 2, there is no time available to update the target, so the G&N must be failed.

COMMENT: None

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center, MSC Memo 68-FM53-89, March 4, 1968.
2. Evaluation of Variations in Touchdown Target Placement for the A-2/CSM 020 (Apollo 6) Guidance and Navigation (G&N) System. TRW IC No. 3423.5-228, March 22, 1968.

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-86	G&N failed and		
	A. 20g and thermal limits not exceeded using zero lift entry.	A. Allow SCS rolling entry. Note: Entry attitudes will be provided by retro.	
	B. 20g and thermal limits exceeded using zero lift entry.	B. Recommend to flight performance lifting entry (roll left 70 degrees or full lift).	
	C. FIDO's biased overshoot line exceeded.	C. Allow SCS rolling entry with initial bank angle of 180 degrees. (lift vector down).	
	D. Zero lift 3500 n.mi. overshoot line exceeded.	D. Recommend to flight performance lifting entry (lift vector down)	

PHILOSOPHY:

The entry corridor has been divided up into several areas where rolling entries or backup bank angle entries can be flown. In these areas the CM will not exceed 20g and the CM will splashdown not more than 3000 n.mi. from the entry interface point.

COMMENTS:

One exception to the above is when a lift-vector-down entry is flown throughout the reentry. For this type of entry, the CM will experience considerably more than 20g and the CM will not be recovered.

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Plotboards for the Mission Control Center. MSC Memo 68-FM53-89, March 4, 1968.
2. Ranges for the A-2/CSM 020 Mission Backup Bank Angle Modes. TRW IC No. 3423.5-233, March 14, 1968.

Date:

Verified by: J. C. Harpold

Revision No./Date A 2/28/68

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-87	G&N entry exceeds the (V , γ) 400K heatshield bondline thermal limit	GNC fail G&N (RTC 41) after maneuver to entry attitude, fly recommended SCS entry.	<u>Note:</u> The heatshield bondline limits are displayed on the (V , γ) 400K plots.

PHILOSOPHY:

The reentry trajectory flight limits must prevent failure of the heat shield.

COMMENTS: There are no thermal limits for Apollo 6.

REFERENCE:

1. Thermal limit lines for the Apollo 6 Mission Entry Trajectory. MSC Memo ES5/2-29/38M, March 1, 1968.

14

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-88	Target point is behind predicted entry point by <u>> n.mi.</u> and entry velocity at <u>400K ft</u> <u>>26 000 fps</u> (assumes target point cannot be updated).	GNC fail G&N (RTC 41) after maneuver to entry attitude fly recommended SCS entry.	<u>Notes:</u> <ol style="list-style-type: none"> 1. AGC assumes the target point is always in front of its present position until the final phase entry guidance is initiated. 2. Allowing G&N entry will result in large miss distances.

PHILOSOPHY:

In the event that the target point is near or behind the entry interface point, the G&N system will fly a longer trajectory than the SCS mode entry. This is due to the fact that the G&N assumes the target point is always in front of its present position until the final phase entry logic is initiated.

COMMENT:

If this condition is encountered during the mission, a real-time trade-off must be made between failing the G&N and landing close to the recovery forces.

REFERENCE:

1. Evaluation of Variations in Touchdown Target Placement for the A-2/CSM 020 (Apollo 6) Guidance and Navigation (G&N) System. TRW IC No. 3423.5-228, March 22, 1968.

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
4-89	Predicted G&N entry range with SPS 2 burn >2700 n.mi. or <2000 n.mi.	Update the entry target point before the SPS 2 burn.	<p><u>Notes:</u></p> <ol style="list-style-type: none"> 1. Entry range is measured from 400K ft to the predicted IP. 2. The target point will be updated to 2500 n.mi. unless recovery, land IP or G constraints exist. 3. The update will be generated by GDO as an EMU load. 4. The 2700 n.mi. limit is a maximum G&N entry range constraint with SPS 2 burn entry conditions. 5. The 2000 n.mi. limit is the minimum entry range for a nominal heat test with a G&N entry and SPS 2 burn entry condition. 6. Target point longitude will not be updated to a longitude east of 125 degrees west longitude.

PHILOSOPHY:

For the nominal and 3σ end-of-mission conditions, the G&N will guide the CM to the target point if the entry range is kept between 2000 and 2700 n.mi. from the entry interface point. The 2700 n.mi. is a G&N maximum range limit and the 2000 n. mi. is a minimum thermal test condition limit.

COMMENT: None

REFERENCES:

1. A-2/CSM 020 (Apollo 6) Entry Guidance and Navigation (G&N) System Operation. TRW IC No. 3423-5-230, March 19, 1968.
2. Spacecraft Dispersion Analysis for Apollo 6 (A-2 or AS-502/CSM 020). MSC IN 68-FM-75, March 15, 1968.
3. Apollo 6 High Probability Landing Areas. MSC Memo 68-FM53-98, March 13, 1968.

Date:

Verified by: J. C. Harpold

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
5-34	S-IVB stage common bulkhead delta pressure reaches or exceeds:	<p>A. Minus 20 psid Plus 30 psid</p> <p>B. Minus 26 psid Plus 36 psid</p>	<p><u>Cues:</u></p> <ol style="list-style-type: none"> 1. Fuel and LOX tank ullage pressure. 2. Fuel and LOX tank vent valve positions. 3. Fuel and LOX pump inlet pressure. <p><u>Notes:</u></p> <ol style="list-style-type: none"> 1. BSE #1 command LH₂ and/or LOX tank vent open or closed to maintain the delta pressure within safe limits. 2. BSE #1 recommend spacecraft separation to a safe distance. 3. The minimum recommended distance between the S-IVB and the S/C is 2240 feet. 4. The bulkhead will structurally fail at the ultimate limits of minus 32.2 psid or plus 42.0 psid.

PHILOSOPHY:

If the S-IVB stage common bulkhead data pressure reaches or exceeds specific limits during earth orbit, rule 5-34 recommends spacecraft separation to a minimum distance of 2240 ft. This is required because of the possibility of an impending S-IVB explosion.

COMMENTS:

The separation procedure to obtain this desired minimum separation distance was examined in the reference, and the results indicate that it is not achieved until 41.7 seconds after the initiation of the separation sequence. This distance represents a probability of impact of 0.0001. Mr. Jack Kamman has been made aware of the above results.

REFERENCE:

Change 2 for MSC IN 68-FM-45. Mission A-2/CSM 020 (Apollo 6) Separation and Recontact Analysis Summary Document. February 16, 1968.

Date:

Verified by: M. L. Williamson

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
10-7	G&N fail and no second S-IVB burn possible. GNC:	<u>Perform SPS deorbit.</u> 1. Trasmit G&N Fail (RTC 41) if required.	Notes: 1. Normally an SPS deorbit sequence will begin at CRO with the S-IVB/CSM separation and direct ullage.

PHILOSOPHY:

If a G&N failure occurs during earth orbit and no second S-IVB burn follows, this rule specifies that an SPS deorbit be initiated normally at CRO with CSM/S-IVB separation followed by 5 seconds of ground-commanded ullage.

COMMENT:

The procedures for the above rule were discussed with Mr. Jack Kamman (FCD), and the FAB, MPAD was advised that the separation sequence would be altered to reflect a 10-second direct ullage following separation rather than a 5 second one. The procedure, as altered, will then be the same as the one recommended for the Apollo 4 mission under the same conditions. The relative motion for this sequence is examined in the reference, and no recontact problems are present.

REFERENCE:

Apollo 6 Separation and Recontact Analysis Summary Document. MSC IN 68-FM-45, February 16, 1968.

Date:

Verified by: M. I. Williamson

Rule no.	Condition/Malfunction	Ruling	Notes/Comments/SOP's
10-12	FDO informs flight that CSM may recontact S-IVB during SPS 1 burn.	GNC transmit: 1. Ullage (RTG 22) at initiation of pitch or yaw rate to SPS 1 attitude. 2. Reset ullage (RTG 23) after 10 sec.	

PHILOSOPHY:

If a contingency develops during the TLI of the Apollo 6 mission and results in the S-IVB failing APS to orient the spacecraft to the first SPS ignition attitude, recontact is possible. This possibility was analyzed in reference 1, and the results indicated that for APS failures occurring earlier than 11.697.5 seconds g.e.t. (or prior to 49 seconds of nominal TLI shutdown), no direct ullage maneuver prior to SPS-1 ignition is required. However, for APS failures occurring on or after this time, recontact becomes a problem.

COMMENT:

To alleviate this potential problem, reference 1 recommended that a ground-commanded ullage be performed during the CSM reorientation maneuver to the SPS-1 ignition attitude. This procedure was compared to an alternate one proposed in the Apollo 6 Final Mission Rules, 10-12. The alternate was examined in reference 2, with the recommendation that it be deleted as unfeasible.

Revision A of these same rules now indicates that the ground-commanded ullage technique will be employed instead of the alternate. To determine the exact time to initiate the direct ullage and the duration of the ullage, an optimization analysis was performed (ref. 3). Briefly, the results recommend that the ullage be initiated 12.5 seconds after initiation of CSM reorientation to the SPS-1 attitude for a duration of 10 seconds.

A minimum separation range of 155 ft (CSM c.g. to S-IVB c.g.) will be generated by this maneuver for any CSM reorientation rate from 2 to 6 deg/sec, and for the nominal reorientation rate of 4 deg/sec, the separation range is optimal.

This procedure has been discussed with Mr. Jack Kamman and will be handled through real-time procedures.

REFERENCES:

1. Donahoo, M. E.: Relative Motion of CSM With Respect to S-IVB During First SPS Burn for Early TLI Shutdown. MSC Memo 68-FM37-86, February 26, 1968.
2. Donahoo, M. E.: Recommended Separation and Orientation Procedure Following an Early TLI Shutdown for the Apollo 6 Mission. MSC Memo 68-FM37-96, March 4, 1968.
3. Williamson, M. L.: Optimum Ground-Commanded CSM Ullage Sequence Recommended for Use Prior to SPS-1 for TLI Contingencies with S-IVB/APS failure, Apollo 6 Mission. MSC Memo 68-FM37-126, March 1968.

Date:

Verified by: M. L. Williamson

REFERENCE

Mission Planning and Analysis Division: MPAD Verification of Apollo 5
(AS-204/LM-1) Flight Mission Rules. MSC IN 68-FM-19, January 22, 1968.